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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN NO. 84.

A. D. MELVIN, CHIEF OF BUREAU.

HAMPDEN-SIDNEY COLLEGE
Hampden-Sidney, Va.

INVESTIGATIONS IN THE MANUFACTURE AND STORAGE OF BUTTER.

I.—THE KEEPING QUALITIES OF BUTTER MADE UNDER DIFFERENT CONDITIONS AND STORED AT DIFFERENT TEMPERATURES.

BY

C. E. GRAY,

Dairy Expert in Charge of Butter Investigations, Dairy Division, Bureau of Animal Industry.

WITH REMARKS ON THE SCORING OF THE BUTTER.

BY

G. L. McKAY,

Professor of Dairying, Iowa State College.

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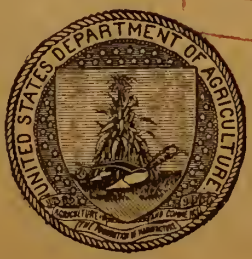

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WASHINGTON:

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1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., April 19, 1906.

Sir: I have the honor to transmit herewith, for publication as a bulletin of this Bureau, a report of certain investigations made by the Dairy Division in the manufacture and storage of butter. This represents the beginning of an important line of work, which has been undertaken with the object of giving practical assistance to the butter trade.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

This bulletin is the first of a series to be issued dealing with investigations in the manufacture and storage of butter, a line of work recently taken up by the Dairy Division. Every step in the making and storage of butter is so intimately connected with every other step that the work of the experts assigned to these studies is never complete at any stage, but the results will be published from time to time as facts enough are gathered to warrant publication. The reports of this work will appear under the general title of "Investigations in the Manufacture and Storage of Butter," with such subtitles as will indicate the particular line or phase of work discussed in each bulletin.

The present number treats of the keeping qualities of butter made under different conditions and stored at different temperatures. The plan of this investigation is to study the keeping qualities of butter—

(1) As affected by temperature of storing.

(2) As affected by pasteurization of cream.

(3) As affected by salting.

(4) As affected by package in which it is stored, as (*a*) tubs, and (*b*) cans so-called hermetically sealed.

(5) As affected by air in the package, as in (*a*) cans full, and (*b*) cans partially full.

This work was outlined by Mr. C. E. Gray, dairy expert in the Dairy Division, and is being carried out under his supervision. This report gives the results of the first season's work (1905–6). The experiments are being continued, and such portions of the work as may seem to be incomplete or inconclusive are already in process of repeating. It is thought advisable to make this preliminary report at this time, however, so that persons storing butter may have during the coming season the results thus far obtained, and any advantages that may be derived from them.

The butter used in these experiments was made by Mr. Gray, some at Topeka, Kans., and some at Monticello, Iowa, and was stored in special rooms built and equipped for the Dairy Division in Chicago, Ill., by Messrs. A. Booth & Co.

The Iowa Agricultural Experiment Station participated in the work by furnishing the services of Prof. G. L. McKay as expert in scoring the butter. He was assisted by Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. Their excellent judgment of the quality of butter has added materially to the completeness and value of the work. Professor McKay's statement concerning the scoring follows Mr. Gray's report of the test.

ED. H. WEBSTER,
Chief of the Dairy Division.

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INVESTIGATIONS IN THE MANUFACTURE AND STORAGE OF BUTTER.

THE KEEPING QUALITIES OF BUTTER MADE UNDER DIFFERENT CONDITIONS AND STORED AT DIFFERENT TEMPERATURES.

By C. E. Gray.

MAKING THE BUTTER.

As shown in Table I, all butter used in this investigation was prepared from five lots of cream, each lot containing enough butter fat to make about 1,200 pounds of butter, or two churnings. The quality of the cream in lots 1, 2, and 3 was about the same, all being sour. The quality of lots 4 and 5 was good, the cream being perfectly sweet. The cream in lot 5 was the better of the two, having been received at the creamery on the same day it was separated. Each of lots 1, 2, and 3 was mixed thoroughly in a vat, then divided into two parts about equally, one part being marked A and the other B, as shown in the table. There being in the creamery no vats of sufficient capacity to hold either lots 4 or 5, the cans of cream in each lot were divided into two parts, which were also marked A and B, respectively. The parts from each lot marked A were not pasteurized; the parts marked B were pasteurized.

Each churning after washing was salted to contain a low percentage of salt, and worked about the usual number of revolutions. Half of each churning was then removed from the churn and packed. To the parts remaining in the churn more salt was added and the butter was worked just enough to incorporate the salt evenly. This method of procedure gave from each lot of cream one churning of butter from unpasteurized cream and one churning from pasteurized cream, one-half of each churning with a low percentage of salt and the other half with a higher percentage of salt.

The system used in marking gave to each kind of butter three symbols, the first (1, 2, 3, 4, or 5) denoting the lot of cream from which the butter was made, the second (A or B) whether the cream was unpasteurized or pasteurized, and the third (L or H) whether the butter contained a low or high percentage of salt. For example, 1 A L would indicate the butter from the first lot of cream, unpasteurized, and lightly salted; 1 A H, from first lot of cream, unpasteurized, heavily salted; 1 B H, from first lot of cream, pasteurized, heavily salted; 1 B L, from first lot of cream, pasteurized, lightly salted; 2 A L, from second lot of cream, unpasteurized, lightly salted, etc.

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TABLE I.—*Details of butter making and composition of butter.*

	Lot of cream No. 1, taken June 30, 1905; condition sour; quality fair; acidity 0.560 per cent.				Lot of cream No. 2, taken June 30, 1905; condition sour; quality fair; acidity 0.575 per cent.				Lot of cream No. 3, taken June 30, 1905; condition sour; quality fair; acidity 0.558 per cent.				Lot of cream No. 4, taken July 10, 1905; condition sweet; quality good; acidity not taken.				Lot of cream No. 5, taken July 10, 1905; condition sweet; quality very good; acidity not taken.			
	1 A.		1 B.		2 A.		2 B.		3 A.		3 B.		4 A.		4 B.		5 A.		5 B.	
Pasteurized	.....		165°–170° F.		.....		165°–170° F.		.....		165°–170° F.		.....		170° F.		.....		170° F.	
Starter added	10 p. ct.		10 p ct.		10 p. ct.		10 p. ct.		10 p. ct.		10 p. ct.		10 p. ct.		10 p. ct.		10 p. ct.		10 p. ct.	
Fat	29.3 p. ct.		29.2 p. ct.		29.4 p. ct.		29.3 p. ct.		31.4 p. ct.		31.6 p. ct.		32 p. ct.		34 p. ct.		39 p. ct.		37 p. ct.	
Time held before churning	6 hrs.		3 h. 55 m.		6 h. 25 m.		6 h. 40 m.		21 h. 40 m.		20 h. 40 m.		2 h. 42 m.		6 h. 55 m.		18 h. 10 m.		22 h. 40 m.	
Acidity when churned	0.576 p. ct.		0.576 p. ct.		0.594 p. ct.		0.576 p. ct.		0.576 p. ct.		0. 594 p. ct.		0.493 p. ct.		0.375 p. ct.		0.425 p. ct.		0.350 p. ct.	
Amount of coloring added	4 ounces		4 ounces		4.4 ounces.		4.4 ounces.		4.5 ounces.		4.5 ounces.		4 ounces		4 ounces		4 ounces		4 ounces.	
Temperature of churning	54° F.		54° F.		54° F.		54° F.		57° F.		56° F.		57° F.		55° F.		54° F.		55° F.	
Time for churning	30 min		1 h		35 m		1 h. 5 m.		30 m		50 m		32 m		32 m		50 m		47 m.	
Wash water used	50 gallons		50 gallons		50 gallons		50 gallons		50 gallons		50 gallons		50 gallons		50 gallons		50 gallons		50 gallons.	
Temperature of wash water	54° F.		54° F.		54° F.		54° F.		57° F.		56° F.		53° F.		53° F.		53° F.		53° F.	
Salt added	25 pounds		25 pounds		23 pounds		23 pounds		22 pounds		25 pounds		22 pounds		28 pounds		28 pounds		22 pounds.	
Revolutions worked	18		19		25		25		18		16		18		18		18		18.	
	1 A L.	1 A H.	1 B L.	1 B H.	2 A L.	2 A H.	2 B L.	2 B H.	3 A L.	3 A H.	3 B L.	3 B H.	4 A L.	4 A H.	4 B L.	4 B H.	5 A L.	5 A H.	5 B L.	5 B H.
Salt added.....pounds	.....	16	.....	16	.....	15	.....	15	.....	12	.....	10	.....	18	.....	20	.....	18	.....	20
Revolutions worked	.....	11	.....	11	.....	10	.....	10	.....	7	.....	7	.....	6	.....	9	.....	6	.....	9
Analysis:																				
Moisture.....per cent	12.60	12.95	12.82	13.12	15.30	14.74	14.43	14.63	12.42	12.80	12.05	12.00	15.00	13.07	12.68	13.59	11.59	12.59	13.03	13.12
Salt.....do	1.02	3.20	1.10	2.87	2.00	3.16	1.52	3.28	1.78	4.83	1.51	3.72	1.80	3.61	1.46	4.65	1.60	2.38	1.32	3.16
Fat.....do	85.09	82.63	85.01	83.01	81.30	80.97	82.64	80.61	84.53	80.80	85.27	83.24	83.38	82.22	85.22	81.27	84.95	84.64	84.96	83.26
Solids not salt or fat.do	1.29	1.22	1.07	1.00	1.40	1.13	1.41	1.48	1.27	1.57	1.17	1.04	.82	1.10	.64	.49	1.86	.39	.69	.46

PACKING.

The tubs in which the butter was packed were of spruce, all being thoroughly steamed and paraffined inside before packing. Tubs of 20 pounds capacity were used in packing butter from lots 1, 2, and 3, and tubs of 25 pounds capacity in packing butter from lots 4 and 5. All cans were made of the best quality of tin. Cans of the so-called 3-pound capacity, however (those in which butter from lots 1, 2, and 3 was packed), when full held 3¼ pounds. Cans in which butter from lots 4 and 5 was packed held when full exactly 3 pounds.

From each kind of butter made from lots of cream 1, 2, and 3 there were packed 9 tubs, holding 20 pounds each; 12 cans, 3¼ pounds each; 12 cans partly full, 3 pounds each; 12 cans partly full, 2½ pounds each; and from each kind of butter from lots 4 and 5 there were packed 9 tubs of 25 pounds each, 12 cans of 3 pounds each, and 12 cans partly full, 2½ pounds each, making in all 180 tubs, containing 3,960 pounds, 624 cans, containing 1,788 pounds, a total of 5,748 pounds of butter. Cans, partly full were used to note the effect of air on the keeping qualities of the butter.

STORAGE.

The butter from lots of cream 1, 2, and 3 was held at a temperature of + 32° F. from July 2 until July 18, when it was shipped by refrigerator freight to the storage rooms, where it arrived in good condition without having become warm. The butter from lots 4 and 5 was held at a temperature of about 40° F. from July 11 until July 20, when it was shipped by refrigerator freight to the storage rooms, arriving July 21 and being placed in storage July 22.

Four different storage rooms were used, one held at −10° F., a second at +10° F., a third at +32° F., and a vestibule having a variable temperature. The records, as kept by recording thermometers, indicate that there was very little variation in the temperatures of the first three rooms. A recording thermometer in the vestibule shows variations of temperature from 20° to 65° F. However, the greater part of the time the temperature was between 30° and 50° F.

Three tubs, 3 full cans, and 3 partly full cans from each kind of butter were placed in the room at −10° F., the same kind and number of packages in the room at +10° F., and the same in the room at +32° F. Cans similar to those placed in the other rooms, but no tubs, were stored in the vestibule. The object in storing triplicate packages at each temperature was to furnish butter for the three scorings.

SCORING.

The butter was scored by Prof. G. L. McKay, professor of dairying at the Iowa State College, and Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. The first scoring was made on July 22, just

before the butter was placed in the storage room. At that time only one tub of each kind of butter was examined, it being assumed that the quality of each kind in all packages at that time was the same, the butter having been held only a short time and at low temperatures. The second scoring was made December 21 and 22, 1905, after the butter had been in storage five months. The butter scored at this time was removed December 18, 1905, from the rooms at −10°, +10°, and +32° F. and placed in the vestibule, the temperature of the vestibule at the time of scoring being 50° and 55° F. The third scoring was made March 22 and 23, 1906, after the butter had been in storage eight months. The butter scored at this time was removed from storage in Chicago March 20, 1906, and shipped by refrigerator freight to the Iowa Experiment Station, Ames, Iowa, where it was examined, as stated, on March 22 and 23, 1906.

All scores made at the times above stated, with comments as to the quality and condition of the butter at each scoring, are given in Tables II, III, IV, V, and VI.

TABLE II.—*Scores of all butter made from cream of lot No. 1, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
1 A L, containing 1.02 per cent salt:									
Tubs and cans	*a* 88								
Tubs, 20 pounds		*b* 93	90⅛	*c* 92½	90	*a* 90	86		
Cans, full, 3¼ pounds		93⅜	88	93½	90	91	*d* 88½	*e* 80	*f* 80
Cans, 3 pounds		93⅜	88	93	90	90½	88	*g* 77	*f* 80
Cans, 2½ pounds		91⅛	85	91	85	88¼	86	72	80
1 A H, containing 3.20 per cent salt:									
Tubs and cans	*h* 89								
Tubs, 20 pounds		90	*c* 88	*c* 89⅜	*i* 86	*h* 85	*f* 84		
Cans, full, 3¼ pounds		91⅛	90	92	89	90	88	*e* 85	87
Cans, 3 pounds		91	89⅛	91⅛	88⅜	89¼	87	*e* 82	87
Cans, 2½ pounds		88	85	89⅛	84	84	84	*e* 80	80
1 B L, containing 1.10 per cent salt:									
Tubs and cans	*c* 91								
Tubs, 20 pounds		93	*k* 91¼	92	*k* 91½	89	*l* 88		
Cans, full, 3¼ pounds		92⅛	90⅛	92	*f* 87	90	*f* 90	*f* 80	*m* 80
Cans, 3 pounds		92⅛	90¼	91⅜	87	89¼	90	78	*m* 80
Cans, 2½ pounds		*n* 91	87	91	84	88	89	77	*m* 80
1 B H, containing 2.87 per cent salt:									
Tubs and cans	*c* 91								
Tubs, 20 pounds		*o* 90½	*p* 87	90	*p* 87	88	*p* 87		
Cans, full, 3¼ pounds		91⅛	89	91	88	89½	*b* 90	*f* 80	*p* 83
Cans, 3 pounds		91⅛	88	91⅛	88	89	89	*f* 78	*p* 82
Cans, 2½ pounds		88⅛	87	89	82	86	87	*f* 73	*p* 82

a Very unclean; fishy; decided old cream flavor.
b Trace fishy.
c Fishy.
d Cheesy and tallowy.
e Rancid.
f Cheesy.
g Rancid and sour.
h Salt mackerel.
i Fishy; old cream.
j Fishy; very poor.
k Slightly cheesy.
l Old and stale.
m Very cheesy.
n Turpentine; old.
o Not clean; old cream.
p Stale; old cream.

TABLE III.—*Scores of all butter made from cream of lot No. 2, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
2 A L, containing 2 per cent salt:									
Tubs and cans	a 91⅛								
Tubs, 20 pounds		92⅛	b 89	c 89	b 89	d 91	b 88		
Cans, full, 3¼ pounds		93	90	92	e 89	92	90	f 90	g 84
Cans, 3 pounds		92⅜	90	91⅜	e 89	91¼	90	f 89⅛	84
Cans, 2½ pounds		88½	82	89	e 87	90	80	f 87	g 84
2 A H, containing 3.16 per cent salt:									
Tubs and cans	h 89⅛								
Tubs, 20 pounds		i 91	j 89	i 90	k 88⅛	89	l 84		
Cans, full, 3¼ pounds		91	m 87⅛	91	82	90	l 88½	f 89	n 86
Cans, 3 pounds		90	87	90	82	89	88½	f 88	84
Cans, 2½ pounds		87	80	87	78	86	70	f 87	84
2 B L, containing 1.52 per cent salt:									
Tubs and cans	91⅛								
Tubs, 20 pounds		o 91	i 88⅛	i 90½	p 88	q 88	q 82		
Cans, full, 3¼ pounds		91	k 89	90½	o 88	90	e 89	88	r 86
Cans, 3 pounds		90	j 84	90	88	90	84	86	86
Cans, 2½ pounds		89½	84	s 88	82	86	84	85	84
2 B H, containing 3.28 per cent salt:									
Tubs and cans	t 89								
Tubs, 20 pounds		89	85	i 87½	85	k 86	80		
Cans, full, 3¼ pounds		90	j 86	u 89	85	88	87	86	86
Cans, 3 pounds		89¼	85	89	84⅛	87⅛	87	85	86
Cans, 2½ pounds		88	80	87	83	86	84	82	80

a Slightly unclean.
b Old cream; cheesy.
c Very fishy.
d Turpentine.
e Cheesy.
f Rancid.
g Very cheesy.
h Pronounced fishy; undesirable; unclean; turpentine flavor.
i Fishy.
j Fishy; old.
k Oily; fishy.
l Oily.
m Oily; fishy; old.
n Stale; old cream.
o Trace fishy.
p Oily; trace fishy.
q Rancid; trace fishy.
r Rancid; stale; cheesy.
s Rancid; turpentine.
t Strong, fishy; unclean flavor; old cream; dirty can flavor.
u Very metallic.

TABLE IV.—*Scores of all butter made from cream of lot No. 3, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.	Scored Dec. 21, 1905.	Scored Mar. 22, 1906.
3 A L, containing 1.78 per cent salt:									
Tubs and cans	89								
Tubs, 20 pounds		92	a 88	b 91⅞	c 87½	d 91⅛	e 84		
Cans, full, 3½ pounds		92½	f 83	92	g 82	91	f 87	89	f 88
Cans, 3 pounds		92	83	92	h 80	91	f 87	88	f 88
Cans, 2½ pounds		89	87	91	h 78	91	f 87	87	f 88
3 A H, containing 4.83 per cent salt:									
Tubs and cans	i 89								
Tubs, 20 pounds		j 88	k 87	j 87½	k 85	j 84	j 78		
Cans, full, 3½ pounds		k 90	i 87	90	86	87	j 86	l 87	m 86
Cans, 3 pounds		k 87	86	89	h 84	86½	87	85	n 82
Cans, 2½ pounds		k 84	h 80	84	h 78	82	88	82	n 76
3 B L, containing 1.51 per cent salt:									
Tubs and cans	o 89								
Tubs, 20 pounds		92½	87	92	88	91	84		
Cans, full, 3½ pounds		92	87	91½	f 87	90	e 86	p 89	f 85
Cans, 3 pounds		92	87	91½	f 87	90	e 86	88	f 85
Cans, 2½ pounds		q 89½	80	90	f 84	89	e 84	86	f 85
3 B H, containing 3.72 per cent salt:									
Tubs and cans	r 89								
Tubs, 20 pounds		k 87	h 85	86	h 85	82	84		
Cans, full, 3½ pounds		88	h 85	87	h 85	85	s 84	86	l 88
Cans, 3 pounds		88	h 85	87	h 85	85	s 84	86	86
Cans, 2½ pounds		84	h 83	86	h 83	82	82	84	n 80

a Oily; fishy; cheesy.
b Sour.
c Oily; cheesy.
d Turpentine.
e Very cheesy.
f Cheesy.
g Cheesy; stale.
h Very poor.
i Salt mackerel.
j Very fishy.
k Fishy.
l Oily.
m Old; stale.
n Oily; fishy.
o Not clean.
p Old; rancid.
q Metallic.
r Weedy.
s Fishy; very poor.

TABLE V.—*Scores of all butter made from cream of lot No. 4, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.
4 A L, containing 1.80 per cent salt:									
Tubs and cans	a 95½								
Tubs, 20 pounds		93½	b 93½	93¾	93	c 89	91		
Cans, full, 3 pounds		93	92	d 91½	93	91	88	89	e 82
Cans, 2½ pounds		93	90	91⅛	f 84	g 88	84	86	e 82
4 A H, containing 3.60 per cent salt:									
Tubs and cans	h 94								
Tubs, 20 pounds		i 92	c 92½	j 91½	92½	f 89	k 88		
Cans, full, 3 pounds		91½	92½	91	86	89	85	l 86	90
Cans, 2½ pounds		91½	92	91	m 85	87	80	l 84	80
4 B L, containing 1.46 per cent salt:									
Tubs and cans	n 97								
Tubs, 20 pounds		b 94	n 93½	93¾	93	o 90	86		
Cans, full, 3 pounds		95½	92	d 92½	93	89½	90	e 87	86
Cans, 2½ pounds		93	92	d 92	92	88	90	p 84	84
4 B H, containing 4.65 per cent salt:									
Tubs and cans	q 95								
Tubs, 20 pounds		93	93	92½	93	m 89⅛	88		
Cans, full, 3 pounds		92½	92	92½	92	r 89	85	l 88	86
Cans, 2½ pounds		92½	91	91½	88	r 87	81	l 84	83

a Slightly flat.
b Very good.
c Oily; trace fishy.
d Metallic.
e Cheesy.
f Fishy; oily.
g Rancid; old.
h Sweet but flat.
i Trace fishy.
j Stale; trace fishy.
k Very fishy.
l Raucid.
m Fishy.
n Very clean but not pronounced.
o Old; stale.
p Very cheesy.
q Brine flavor; butter flavor not pronounced.
r Fishy; stale.

TABLE VI.—*Scores of all butter made from cream of lot No. 5, with remarks as to flavor.*

	Scored July 22, 1905, before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
		Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.	Scored Dec. 22, 1905.	Scored Mar. 22, 1906.
5 A L, containing 1.60 per cent salt:									
Tubs and cans	[a] 94⅛								
Tubs, 20 pounds		92	[b] 93⅛	92	93⅛	[c] 90	90		
Cans full, 3 pounds		92	93	92	[d] 91	[c] 90	[e] 88	84	[f] 85
Cans, 2½ pounds		[d] 92	91	[d] 91½	88	[g] 88	80	80	[f] 85
5 A H, containing 2.38 per cent salt:									
Tubs and cans	[h] 94⅛								
Tubs, 20 pounds		91⅛	93	[i] 92	93	[c] 88	91		
Cans full, 3 pounds		[d] 91	93	92	[j] 90	89½	[k] 88	78	85
Cans, 2½ pounds		[d] 90½	90	90	87	84	82	73	88
5 B L, containing 1.32 per cent salt:									
Tubs and cans	[l] 97								
Tubs, 20 pounds		93	94	93	93	[m] 91	90		
Cans full, 3 pounds		[n] 93	93½	[n] 93	[d] 91⅛	80	90	86	80
Cans, 2½ pounds		93	92	92½	91½	86	90	80	78
5 B H, containing 3.16 per cent salt:									
Tubs and cans	[o] 95⅛								
Tubs, 20 pounds		93	[p] 93	[i] 93	92⅜	[q] 90½	90		
Cans full, 3 pounds		93	93½	[d] 92⅛	91⅛	[r] 89½	88½	86	90⅛
Cans, 2½ pounds		93	90½	92	91½	88	82	82	89⅛

[a] Slightly cooked; tallowy; shows age.
[b] Very good; fresh.
[c] Fishy.
[d] Metallic.
[e] Cheesy.
[f] Very cheesy.
[g] Very fishy.
[h] Weedy.
[i] Trace fishy.
[j] Oily; fishy.
[k] Oily.
[l] Exceptionally good.
[m] Shows age.
[n] Trace metallic.
[o] Cooked flavor.
[p] Clean but flat.
[q] Trace fishy; old; stale.
[r] Fishy; metallic.

A number of variations in scores may be noted in Tables II, III, IV, V, and VI, and in order that these variations may be studied with greater ease other tables are presented.

EFFECT OF SALT.

The scores in Table VII are from butter in tubs, there being no material difference between the scores of butter in tubs and in cans, as will be shown.

TABLE VII.—*Scores of all butter in tubs, with averages showing differences attributed to percentage of salt.*

	Per cent of salt.	Scores.						
		Before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.	
			Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
1 A L	1.02	88	93	90¼	92½	90	90	86
1 A H	3.20	89	90	88	89½	86	85	84
1 B L	1.10	91	93	91⅛	92	91½	89	88
1 B H	2.87	91	90½	87	90	87	88	87
2 A L	2.00	91½	92½	89	89	89	91	88
2 A H	3.16	89½	91	89	90	88½	89	84
2 B L	1.52	91½	91	88½	90½	88	88	82
2 B H	3.28	89	89	85	87½	85	86	80
3 A L	1.78	89	92	88	91½	87½	91½	84
3 A H	4.83	89	88	87	87½	85	84	78
3 B L	1.51	89	92½	87	92	88	91	84
3 B H	3.72	89	87	85	86	85	82	84
4 A L	1.80	95½	93½	93½	93¼	93	89	91
4 A H	3.61	94	92	92½	91½	92½	89	88
4 B L	1.46	97	94	93½	93½	93	90	86
4 B H	4.65	95	93	93	92½	93	89½	88
5 A L	1.60	94½	92	93½	92	93½	90	90
5 A H	2.38	94½	91½	93	92	93	88	91
5 B L	1.32	97	93	94	93	93	91	90
5 B H	3.16	95½	93	93	93	92½	90¼	90
Averages of lots 1, 2, 3, 4, and 5:								
A L	1.64	91.7	92.6	90.9	91.70	90.60	90.3	87.8
A H	3.44	91.2	90.5	89.9	90.15	89.00	89.0	85.0
Difference	−1.80	.5	2.1	1.0	1.55	1.60	3.3	2.8
B L	1.38	93.1	92.7	90.9	92.20	90.65	89.8	86.0
B H	3.54	91.9	90.5	88.6	89.70	88.55	87.2	85.8
Difference	−2.16	1.2	2.2	2.3	2.50	2.10	2.6	.2
Average of both scorings, lots 1, 2, 3, 4, and 5:								
A L	1.64	.....	91.75		91.15		89.05	
A H	3.44	.....	90.20		89.57		86.00	
Difference	−1.80	.....	1.55		1.58		3.05	
B L	1.38	.....	91.80		91.42		87.90	
B H	3.54	.....	89.55		89.12		86.50	
Difference	−2.16	.....	2.25		2.30		1.40	

In comparing the first two scores in the foregoing table, butter 1 A L and 1 A H, it should be remembered that this butter was from the same churning, but with different percentages of salt, the percentage in 1 A H being 3.20 and in 1 A L 1.02, a difference of 1.18. The scores before storing were 88 and 89, one point in favor of 1 A H, the butter with the greater percentage of salt. The tubs of this butter held at −10° F. scored after five and eight months 3 points and 2½ points, respectively, in favor of the lightly salted butter. Tubs of the same butter held at +10° F. after five and eight months scored,

respectively, 2½ points and 4 points in favor of the light salting. The same butter at +32° F. after five and eight months scored, respectively, 5 points and 2 points in favor of the light salting.

Comparing scores of 5 B L and 5 B H, butter from the same churning containing 1.32 and 3.16 per cent of salt, respectively, or a difference of 1.84 per cent, it will be noted that the scores after five months were exactly the same for butter at −10° and +10° F. After eight months there was a slight difference in favor of light salting. Butter 5 B H when placed in storage scored the highest of the butter with heavy salting, and seemed to have been the least affected by the salt. Throughout the table it will be noted that the butter having the higher score when placed in storage shows the least effect of heavy salting. This being true, it seems that the practice of attempting to cover up undesirable flavors in poor butter by using a large percentage of salt, if butter is stored, would produce results in the opposite direction to those desired.

The average of all scores of butter from unpasteurized cream with light salting compared with the average of the scores of the same butter with heavy salting shows the following:

Difference in percentages of salt, 1.80. Differences in scores of butter held at −10° F. after five and eight months, 2.1 points and 1 point, respectively, in favor of light salting. Average of both scorings, 1.55 points in favor of light salting.

The same butter stored at +10° F. after five and eight months showed, respectively, 1.55 and 1.60 points in favor of light salting. Average of both scorings, 1.57 points.

The same butter stored at +32° F. after five and eight months showed 3.3 and 2.8 points, respectively, in favor of light salting, or an average of 3.05 points.

The average of scores of all butter from pasteurized cream with light salting compared with average scores of the same butter with heavy salting shows a difference in the percentage of salt of 2.16.

Scores of butter at −10° F. after five and eight months show a difference of 2.2 and 2.3 points, respectively, in favor of light salting, or an average of 2.25 points.

The same butter stored at +10° F. after five and eight months shows a difference of 2.5 and 2.1 points, respectively, in favor of light salting, or an average of 2.3 points.

The same butter stored at +32° F. after five and eight months shows a difference of 2.6 and 0.2 points, respectively, in favor of light salting, or an average of 1.40 points.

The only scores indicating that heavy salting was of any advantage were those of the butter held in cans eight months at variable temperatures.

KEEPING QUALITIES OF BUTTER IN FULL CANS AND TUBS.

TABLE VIII.—*Comparison of average scores of butter in full cans and tubs.*

	Scores.					
	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.	
	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
Averages, lots 1, 2, 3, 4, and 5:						
A L in full cans	92.85	89.2	92.15	89.0	91.0	88.3
A L in tubs	92.60	90.9	91.70	90.6	90.3	87.8
Difference in favor of cans	.25	−.7	.45	−.4	.7	.5
Average difference of both scorings	−.22		.025		.6	
A H in full cans	91.0	90.0	91.20	86.6	89.1	87.1
A H in tubs	90.5	89.9	90.15	89.0	87.0	85.0
Difference in favor of cans	.5	.1	1.05	−2.4	2.1	2.1
Average difference of both scorings	.3		−.69		2.1	
B L in full cans	92.4	90.4	91.9	89.30	89.9	89.0
B L in tubs	92.7	90.9	92.2	90.65	89.8	86.0
Difference in favor of cans	−.3	−.5	−.3	−1.35	.1	3.0
Average difference of both scorings	−.4		−.82		1.55	
B H in full cans	90.95	89.1	90.4	88.30	88.2	86.9
B H in tubs	90.50	88.6	89.7	88.55	87.2	85.8
Difference in favor of cans	.45	.5	.7	−.25	1.00	1.1
Average difference of both scorings	.47		.22		1.05	

Comparing the figures in the foregoing table, the average scores of tubs and full cans of A L (pasteurized cream, lightly salted) butter, it will be seen that the butter of five months at −10°, +10°, and +32° F. scored, respectively, 0.25, 0.45, and 0.7 point in favor of cans. After eight months, at −10° and +10° F., scores show 0.7 and 0.4 point, respectively, in favor of tubs, while at +32° F. scores show 0.5 point in favor of cans. The average of both scorings shows for butter held at −10° F. 0.22 point in favor of tubs, and for butter at +10° and +32° F., 0.025 and 0.6 point, respectively, in favor of cans.

Comparing the average scores from A H (unpasteurized cream, heavily salted) butter, after five months at −10°, +10°, and +32° F., the scores show 0.5, 1.05, and 2.1 points in favor of cans. After eight months at +10° F. the scores show 2.4 points in favor of tubs, and at −10° and +32° F. 1 and 2.1 points, respectively, in favor of cans; averages of both scorings showing at −10° and +32° F. 3 and 2.1 points, respectively, in favor of cans, and at +10° F. 0.69 point in favor of tubs.

With B L (pasteurized cream, lightly salted) butter all scores at −10° and +10° F. were slightly in favor of tubs, while at +32° F. butter in cans received an average score a trifle higher than that of the butter in tubs.

Comparing the average scores of B H (pasteurized cream, lightly

salted) butter, all average scores, excepting those of butter held eight months at +10° F., were in favor of cans.

Comparing all scores of butter in tubs with all scores of butter in cans at −10° and +10° F., no material difference is noted. At 32° F. there is a very slight difference in favor of cans.

EFFECT OF AIR IN CANS.

TABLE IX.—*Comparison of average scores of butter in full cans and in partly full cans.*

	Scores.							
	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.		Stored at variable temperatures.	
	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.	Five months.	Eight months.
Averages, lots 1, 2, 3, 4, and 5:								
A L in full cans	92.85	89.2	92.15	89.0	91.0	88.3	86.4	83.8
A L in cans partly full, 2½ pounds	90.80	87.0	90.80	84.4	89.1	83.4	82.4	83.8
Difference in favor of full cans	2.05	2.2	1.35	4.6	1.9	4.9	4.0	.0
Average difference of both scorings	2.12		2.97		3.4		2.0	
A H in full cans	91.0	90.0	91.2	86.6	89.1	87.1	85.0	86.0
A H in cans partly full, 2½ pounds	88.6	85.4	88.3	82.4	84.6	80.8	81.2	81.6
Difference in favor of full cans	2.4	4.6	2.9	4.2	4.5	6.3	3.8	5.4
Average difference of both scorings	2.9		3.55		5.4		4.6	
B L in full cans	92.4	90.4	91.9	89.3	89.9	89.0	85.8	83.4
B L in can spartly full, 2½ pounds	91.2	87.0	90.7	86.7	87.4	87.4	82.4	82.2
Difference in favor of full cans	1.2	3.4	1.2	2.6	2.5	1.6	3.4	1.2
Average difference of both scorings	2.3		1.9		2.05		2.3	
B H in full cans	90.95	89.1	90.4	88.3	88.2	86.9	85.2	86.7
B H in cans partly full, 2½ pounds	89.20	86.3	89.1	85.5	85.8	83.1	81.0	82.9
Difference in favor of full cans	1.75	2.8	1.3	2.8	2.4	3.8	4.2	3.8
Average difference of both scorings	2.27		2.05		3.1		4.0	

Comparing the average scores of butter in full cans and in partially full cans it will be noted that there were differences of 1 to 5 points in favor of the full cans. It does not seem necessary to take up these differences in detail. This deterioration was without doubt due to air in the partially full cans. Since in packing butter in cans there is no necessity for having the cans only partially full, neither is this economical, the writer does not hesitate to state that where the sealing is done at atmospheric pressure the cans should be entirely filled, leaving as little air space as possible. This principle may be applied to packing butter in other packages. The butter should be packed solidly, leaving

as few air spaces as possible. Air having a deteriorating effect on the keeping of storage butter, it would be expected that butter stored in small open packages, as pound prints, would not keep so well as butter in large packages. This is a belief that has already been accepted by many.

EFFECT OF STORAGE TEMPERATURES.

TABLE X.—*Scores of butter stored at −10° F. compared with those of butter stored at +10° F., +32° F., and at variable temperatures.*

	Average scores.				
	A L butter.	A H butter.	B L butter.	B H butter.	Average difference.
Butter in tubs:					
−10° F.	91.75	90.20	91.80	89.55	
+10° F.	91.15	89.57	91.42	89.12	
Difference in favor of −10° F.	.60	.63	.38	.43	.51
−10° F.	91.75	90.20	91.80	89.55	
+32° F.	89.05	86.00	87.90	86.50	
Difference in favor of −10° F.	2.70	4.20	3.90	3.05	3.46
Butter in full cans:					
−10° F.	91.02	90.50	91.40	90.02	
Variable	85.10	85.50	84.60	85.95	
Difference in favor of −10° F.	5.92	5.00	6.80	4.07	5.45

Table X was prepared from average scores which have been given in previous tables. The difference in quality of all butter held in tubs at −10° and +10° F., as shown by average scores, was 0.51 point in favor of the butter held at a temperature of −10° F. The difference in quality of all butter held in tubs at −10° and +32° F. was, as shown by average scores, 3.46 points in favor of the butter held at −10° F. The difference in the quality of the butter in full cans held at −10° F. and at variable temperatures was, as shown by average scores, 5.45 points in favor of the butter held at −10° F.

KEEPING QUALITIES AFTER REMOVAL FROM STORAGE.

Results thus far given practically show only the changes which took place while the butter was in storage, the butter being out of storage only long enough to thaw before scoring. Another matter of as great importance as the keeping qualities of butter when in storage is the keeping qualities of butter after its removal from storage. The butter should be in good condition when it reaches the consumer, and remain good a reasonable length of time. One week would certainly be the minimum, and in many cases the time would be much longer. The butter scored December 21 and 22, 1905, could not be scored a second time without considerable inconvenience. The butter scored March 22 and 23, 1906, was allowed to remain out of cold storage, and the butter in tubs was again scored April 2. The butter was scored at that time by Professor McKay alone, as Mr. Kieffer could not be present. These scores are given in Table XI.

TABLE XI.—*Showing deterioration of storage butter after removal from storage.*

Butter in tubs.	Before storing.	Stored at −10° F.		Stored at +10° F.		Stored at +32° F.	
		Scored Mar. 22, 1906.	Scored Apr. 2, 1906.	Scored Mar. 22, 1906.	Scored Apr. 2, 1906.	Scored Mar. 22, 1906.	Scored Apr. 2, 1906.
1 A L	88	90⅛	75	90	74	86	Very bad.
1 A H	89	88	73	86	72	84	Very bad.
1 B L	91	91¼	75	91¼	74	88	Very bad.
1 B H	91	87	73	87	72	87	Very bad.
2 A L	91⅛	89	75	89	75	88	Very bad.
2 A H	89⅛	89	77	88⅛	76	84	Very bad.
2 B L	91¼	88⅛	74	88	73	82	Very bad.
2 B H	89	85	75	85	75	80	Very bad.
3 A L	89	88	81	87⅛	79	84	Very bad.
3 A H	89	87	76	85	76	78	Very bad.
3 B L	89	87	75	88	74	84	Very bad.
3 B H	89	85	75	85	75	84	Very bad.
4 A L	95⅛	93⅛	92⅛	93	90⅛	91	80
4 A H	94	92⅛	90⅛	92⅛	90	88	80
4 B L	97	93⅛	93	93	90⅛	86	82
4 B H	95	93	92	93	91	88	84
5 A L	94⅛	93⅛	92	93⅛	91	90	80
5 A H	94⅛	93	91	93	90	91	82
5 B L	97	94	93⅛	93	92⅛	90	83
5 B H	95½	93	92⅛	92⅞	91	90	85
Average of above scores of butter from lots 4 and 5	95.37	93.25	92.12	92.97	90.81	94.25	.....
Average of above scores of butter from lots 1, 2, and 3	89.70	87.96	75.33	87.51	74.58	84.08	.....
Average difference in favor of butter from lots 4 and 5	5.67	5.29	16.79	6.46	16.23	5.17	.....

In Table XI, besides the scores of April 2, the scores of March 22 and 23 and those before storing are given. By studying carefully the scores of April 2 differences will be found which may be attributed to salt and temperature. These differences in the butter held at −10° and +10° F. are about the same or perhaps greater than have been noted in previous tables. There are other differences so much greater that those attributed to salt and temperature seem of minor importance.

Looking at the scores of April 2, 1906, it is noted that all scores of butter from the first three lots of cream are very low, while those of the butter from lots 4 and 5 are only about 1 point lower than the scores of the same butter ten days previously. To determine more readily the difference in scores between the butter made from the first three lots of cream and that from the last two lots two averages have been made. These show that the average score of all butter from lots 4 and 5 when first scored was 95.37, while the average score of all butter from lots 1, 2, and 3 was 87, being 5.67 points lower. The average score of all butter from lots 4 and 5, after being in storage at −10° F. eight months, was 93.25. After the butter had been out of storage ten days the average score was 92.12, only 1.13 points lower. The average score of all butter from lots 1, 2, and 3, after being in storage at −10° F. eight months, was 87.96. After the butter had been out of storage ten days the average score was 75.33, or 12.63 points lower, showing that the deterioration of the butter from lots 1, 2, and 3 was more than ten times as great as that from lots 4 and 5. The rate of deterioration of butter held at +10° F. was practically the

same as has just been noted for the butter held at −10° F. The deterioration of all butter held at +32° F. was very marked.

In endeavoring to account for these differences in keeping quality, which have divided the butter into two classes, the first question probably would be, How and from what kind of cream was each class of butter made? For this information we may refer to Table I. As has previously been noted, cream of lots 1, 2, and 3 was sour when received, showing acidities of 0.560, 0.575, and 0.558 per cent, respectively, or between 31 and 32 c. c., Mann's test. The cream in lots 4 and 5 was of good quality and perfectly sweet. The acid development in lots 1, 2, and 3 from the time received until churned was very little, owing to the cream being practically ripe when received. With lots 4 and 5 the percentage of acid developed was not high. In fact, this cream at the time of churning had lower percentages of acid than had lots 1, 2, and 3 when received. Other than these points just mentioned there was practically no difference in the making of the butter. The butter from lots 1, 2, and 3 was held about ten days longer before being placed in storage than was butter from lots 4 and 5; however, it being held at +32° F., the writer is of the opinion that this length of time would not make any material difference. There is without doubt a direct relation between the differences in the cream as shown in Table I and the differences in the keeping qualities of the butter after removal from storage, as shown in Table XI.

SUMMARY.

The results thus far obtained in this investigation may be summarized as follows:

(1) Butter containing low percentages of salt kept better than did butter of the same lot containing higher percentages of salt.

(2) Butter in full cans and tubs at −10° and +10° F. scored about the same. At +32° F. there was a slight difference in favor of cans.

(3) Butter in full cans kept much better than did butter in cans only partially full, the deterioration doubtless being due to the presence of air in the partially full cans.

(4) Butter held at −10° F. kept best, both when in storage and after removal from storage.

(5) Butter made from cream received at the creamery sweet and in good condition kept well while stored at −10° and +10° F.; also after removal from storage, giving results wholly satisfactory.

(6) Butter made from cream received at the creamery sour and in fair condition kept well while in storage at −10° and +10° F., but deteriorated rapidly after removal from storage, giving, on the whole, results which were very unsatisfactory.

REMARKS ON THE SCORING OF THE BUTTER.

By G. L. McKay.

It was the writer's privilege to officiate as judge in conjunction with Mr. P. H. Kieffer, assistant dairy commissioner of Iowa. The judges had no intimation in any of the scorings as to how the different lots were made. The work was all outlined by Mr. Gray and the records were kept in his possession until all scorings were completed, so that there was nothing to influence the judges one way or the other. When the scoring was completed it was found that the butter made from cream received sour scored higher on the second scoring than the first. This was undoubtedly due to many of the odors not being so apparent when the butter was cold or chilled. It has been asserted by some butter merchants in the past that butter made from real sour cream comes out of storage better than that made from mildly acid cream. This impression is undoubtedly due to the undesirable odors not being manifest when the butter was chilled or held in storage for some time. On the final scoring, however, after this butter had stood at a high temperature for some days the butter made from sour cream went off flavor very rapidly, as indicated by the scores.

Another noticeable feature, both in the tubs and in the hermetically sealed cans, was that the fishy flavor was quite pronounced in those lots made from old cream where a high percentage of salt had been used. The high percentage of salt seemed to bring out latent odors and make them more pronounced.

At the second and third scorings it was found that the different lots of butter kept at high temperatures did not have so decided a fishy flavor as the butter held at lower temperatures, as other flavors had now developed which covered up the fishy flavors. The high salting did not impart a fishy flavor to the butter made from cream received sweet, so it would seem to the writer that the odors are in the butter, and the salt simply makes them more pronounced.

It was noticed with regard to the hermetically sealed cans that in the case of those only partly filled, thus having an air space, the butter scored much lower than in the full cans. Mr. Gray had so varied the amount of butter in these cans that different-sized air spaces were left. In some instances where the amount of butter in the can was the smallest and the butter was somewhat loose, thus permitting the air to come in contact with a great portion of it, the quality was much inferior to that of butter tightly packed.

The lightly salted butter held at —10° F. seemed to be almost as fresh at the second scoring as new or freshly made butter.

The fourth scoring was made twelve days after the butter had been taken out of storage and had been for ten of these days kept in an ordinary room at a temperature of about 60° F. At this point all the butter made from cream received sour had deteriorated so much that it was practically packing stock, while that made from cream received sweet, salted lightly, and kept at a low temperature up to the time of leaving the storage room, scored nearly as high at the third scoring.

The lightly salted butter held at the higher temperatures, had a tendency to develop what is known as a cheese flavor. In lots held at +32° F. and above, the cheese flavor seemed to give way to a turpentine or paint flavor at the third scoring. The butter held at —10° F., both in high and low saltings, was more free from foreign odors than that held at +10° F.

It seems to the writer, from his work in scoring the butter and after examining the records kept by Mr. Gray, that light salting and low temperatures gave much the best results for storage butter.

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